Lost in Proxemics: Spatial Behavior for Cross-Cultural HRI

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ABSTRACT
Socio-psychological research hints to the fact that people from different cultures have different preferences with respect to proxemics. Thus, what might be considered normal for one person, could be a violation of a norm for another person. If cultural background influences spatial behaviors, a logical follow-up question would be if a robot should be equipped with different sets of normative motion behaviors for guiding people. In this paper, we provide an overview of research into cultural differences in proxemics and human-robot social norms. We will address culture not at a national level (i.e. Dutch vs. German national culture), but instead at a clustered, supranational level based upon work by [13]. We conclude with foreseen challenges and solutions for analyzing the appropriateness of HRI behaviors in the context of different cultures.

Categories and Subject Descriptors
J.4 [**Computer Applications**]: Social and Behavioral Sciences

General Terms
Human Factors

Keywords
Human-Robot Interaction, Cultural Differences, Public Space, Proxemics.

1. INTRODUCTION
The phrase "as robots start entering our life" might be an understatement, especially in this field of research. It is not so much a question of if, but more when, and how social robots will enter our daily lives. Over a decade ago, Fong et al. [10] provided an overview of the then-current state of robotics, and distinguished six major application areas. In this paper we focus on culture-aware robotics within the service application field, and specifically short-term public interaction robots.

As part of the EU FP7-project Spencer[1], we intend to elicit and evaluate socially normative motion behaviors for a robot which navigates through a crowded environment. The crowded environment is an international airport, where the robot will guide delayed, culturally diverse, passengers from their intercontinental flight to their connecting continental (European) flight. We do not attempt to trivialize the underlying technical challenges to navigate such an environment in an effective and safe way, but we will focus on the aspect of cultural normative behavior.

Research has pointed to evidence suggesting that people explain machine behavior in terms of human behavior. People anthropomorphize, or have "the tendency to imbue the real or imagined behavior of nonhuman agents with humanlike characteristics, motivations, intentions, or emotions" [9]. Examples include a preference for a specific (static) robot head, given a certain task [12], or the perception of cameras as eyes.

In this paper, we will first provide a short overview of human social norms in general, and cross-cultural social norms research specifically (Section 2). We will then discuss human-robot social norms (Section 3), and discuss challenges for cross-cultural human-robot interaction (HRI) research (Section 4).

2. ON SOCIAL NORMS
Social norms are unwritten norms, sustained by feelings of embarrassment and guilt when violated [8], the disapproval of other people, and social sanctions [32]. These norms are situational dependent; norms governing appropriate conduct during a soccer game differ from those which govern a funeral [1]. The definition of social norms we use in this paper is "Rules and standards that are understood by members of a group and that guide and/or constrain social behavior without the force of laws" [6].

Examples of research into human adherence to social norms include series of experiments by Cialdini et al. and Keizer et al. [24]. The norm researched was the social norm of littering in public space. The main findings include that a) people tend to litter more in an already-littered environment, b) littering increased when the norm was made salient, and c) that the violation of one norm (a littered environment) makes violation of others norms more likely – the latter also called a cross-inhibition effect. Similar results have been found for other social norms, such as the norm of "being silent in the library" [1].

While above research provides insightful results, these are not necessarily the social norms that are automatically relevant or applicable for the Spencer project. A norm that ís relevant, is the norm concerning the adherence to one's personal space. Personal space is one of the four proxemics zones defined by Hall [14], and refers to the semi-circular shaped protective bubble people keep around themselves that cannot be invaded without causing some sort of discomfort. In his book, *the Hidden Dimension* [14], Hall indicated the size of one's personal space to be around 45 cm., this being applicable to Northern Americans, and indicating this size to be different for, for instance, Chinese people.

2.1 Personal space is dependent on culture
Several experiments showed that people with different cultural backgrounds have a different sized personal space zone. One

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HRI'14 Workshop on Culture Aware Robotics, 3 March, 2014, Bielefeld, Germany.

[1] http://www.spencer.eu

example dimension to explain cultural differences is the dimension, or maybe division, of cultures into "contact" and "noncontact" cultures. Based upon observations, Hall [14] noted that people from noncontact cultures (Northern European, Northern American countries) maintain a larger personal space compared with their counterparts from contact cultures (Southern European, Southern American, Arab countries).

In one of the experiments, 105 students from three different ethnical groups (Japanese, American and Venezuelan) had a (seated) five-minute conversation with a same-sex, same-nationality confederate [34]. Either in their native language, or in English. They found, when speaking English, participants from the non-contact culture (Japan) sat further apart from each other compared to the contact culture (Venezuela). Within the ethnical groups male participants sat further apart than female participants. Furthermore, when speaking their native language, contact culture participants sat closer together.

Other experiments looking at cross-cultural proxemics distances include the work by Little [27], who used the placement of dolls to infer at which distance people from either the U.S., Sweden, Scotland, Italy and Greece would place people in 19 different social situations, and found similar differences between countries.

Likewise, Høgh-Olesen [19] looked at proxemic differences between cultures, but also at similarities. Based upon the work of Pike [31], he differentiated between two terms; proxethics and proxemics. Proxethics refers to the behaviors and dynamics which are shared by humans – thus being universal. In contrast, proxemics looks at the differences [19]. Høgh-Olesen found six cross-cultural proxethics conventions within six cultures (Greenland, Finland, Denmark, Italy, India and Cameroon). For instance, people leave more room between two strangers compared with one stranger, and the personal space is smaller in social spaces (a café) as compared with non-social spaces (library).

With the knowledge that social norms exist for humans, and these norms can be different for people with different cultural background, a question arises what culture is, and what research has been conducted with regards to cross-cultural human-robot interaction. However, before discussing this in Section 3, we will take a look at the current research in HRI with respect to social norms.

2.2 Human-Robot Social Norms

HRI work related to social norms has mostly been concerned with physical norms, such as approaching someone. Work by Walters [38] focused primarily on the identification of the size of humans' personal space bubble. Takayama & Pantofaru [35] looked at the effect of robot gaze on the approach distance humans keep. They found that when the robot would gaze towards one's legs, men and woman would approach equally close (M=0.28 / 0.30m). However, when the robot gazed towards the participants face, woman maintained a significant larger personal space (M=0.30 m.) compared with men (M=0.24m).

Related to personal space, Dautenhahn et al. [7] looked at the angle of robot approach. In a between-subjects experiment, the majority of participants indicated the robot should bring a remote control from a right-frontal side approach, instead of a full-frontal approach. Koay et al. [25] found comparable results in a longitudinal study, however, over time, participants allowed the PeopleBot to approach equally close from the full-front as from the front-side.

Pandey & Alami (2009) developed and tested a framework for a social robot which (autonomously) conformed to four different social conventions, these being: (1) Maintain right-half portion in a narrow passage, (2, 3) pass and overtake a person from his / her left side. (4) Avoid very close sudden appearance from behind a wall. In a between-subjects experiment (N=8), a 84.7% reduction in unwanted behavior was found [29].

From this we conclude that social norms exist for humans, and that, if equipped with social norms, acceptance and user experience of social robots can be improved.

3. THERE'S CULTURE AND THERE'S CULTURE

Culture is an ambiguous concept. We use the following definition of culture: "a fuzzy set of attitudes, beliefs, and behavioral norms, and basic assumptions and values that are shared by a group of people, and that influence each member's behavior and his/her interpretations of the 'meaning' of other people's behavior" [33]. Triandis divided culture into a subjective and material culture. *Material culture* consists of elements, for instance food, houses and tools. *Subjective culture*, on the other hand refers to the characteristic way in which a specific group perceives its environment [36]. When referring to culture, we are referring to subjective culture.

Usually, when scholars are looking at a culture – and the differences between cultures, the level of analysis is the nation, or sometimes subcultures within a nation. Karahanna et al. [22] defined different levels of cultures, these being supranational, national, and levels within a nation, such as the professional, organizational and the group level.

Over the years, there have been several scholars like Hofstede [18] and Pelto [30] who described differences between national cultures according to different dimensions. In a study by Gelfand et al. [11] participants (N=6823) from over 33 countries were asked to rate the appropriateness of twelve behaviors in fifteen everyday situations, and, whether or not there were clear rules for appropriate behaviors in these situations. It was found that there was a high within-nation agreement about the level of constraint in everyday situations, and a high level of variability between-nations. The nation as unit of analysis appears to have proven to be an useful unit of analysis.

A common belief is that society is becoming more and more individualistic, in part due to IT advances. As Jones [21] puts it: "[…] many researchers find culture to be a dynamic, constantly changing field. Cultures are merging, technology is changing the way we communicate, and globalization is changing the way we trade and interface". Thus, the question arises if cultures as a whole are also becoming more individualistic. Hamamura [15] compared national studies studying individualism-collectivism in the U.S. and Japan over time. In contrast to the common belief they concluded both cultures did not become significantly more individualistic. Similar, Gelfand et al. [11] concluded that social constraint appeared to be more or less stable over time in the United States.

Due to various reasons, some of the 196 countries on this planet will have inhabitants with similar cultural backgrounds. We intend to analyze cultures at the supranational level, here being regional clusters of countries.

3.1 Supranational Level: Clusters of Cultures

According to Gupta et al. [13], three major forces have been used historically to cluster countries, these being (1) geographic

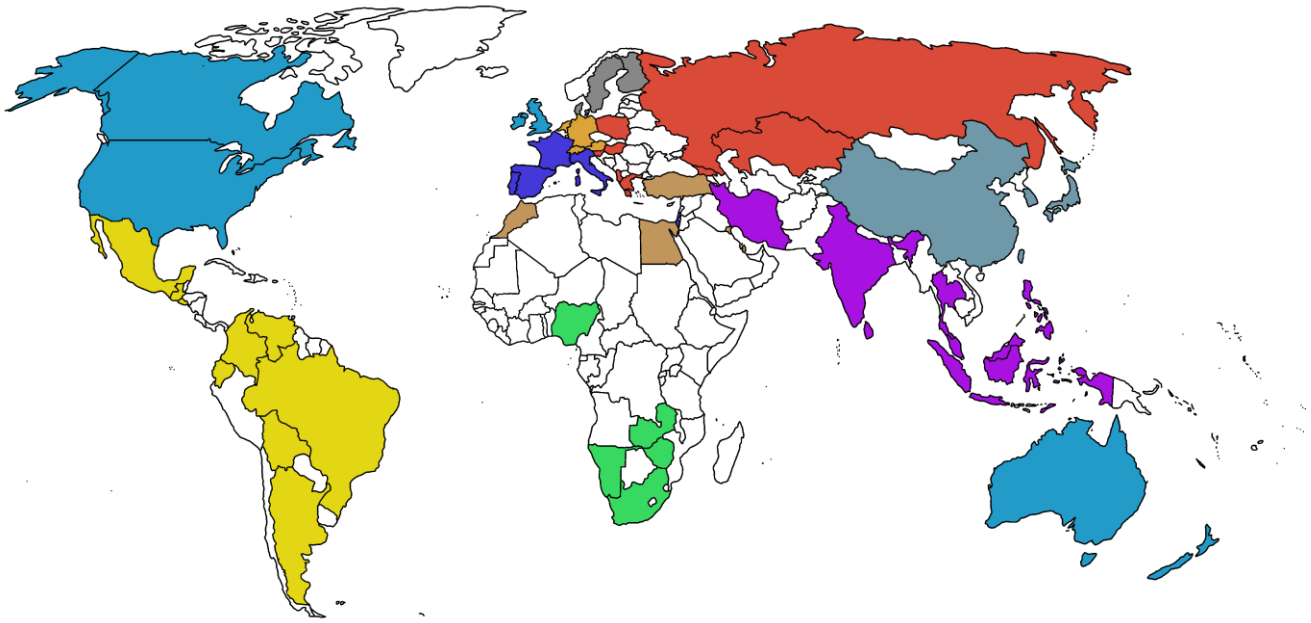

Figure 1. Ten clusters of cultures, figure based upon [13].

Legend: Anglo, Latin Europe, Nordic Europe, Germanic Europe, Eastern Europe, Latin America, Sub-Saharan Africa, Middle East, Southern Asia, Confucian Asia

proximity, (2) mass migration & ethic social capital, and (3) religious and linguistic communality. Societal clustering is a part of the GLOBE project. One of the goals of the authors was to understand similarities and differences among the countries studied within the GLOBE project [20]. As part of this project, 61 nations were clustered into 10 clusters of cultures (see Figure 1, and Appendix I) [13]. Examples include the *Nordic European* cluster containing Finland, Sweden and Denmark, and the *Germanic European* cluster with Austria, Switzerland, the Netherlands and Germany. Appendix I provides the countries contained within each of the ten regional clusters. The remainder of this section will discuss the methodology by which the measures underlying this clustering were developed in more detail.

Among the measures were nine dimensions of culture. These dimensions (*performance orientation, assertiveness, future orientation, humane orientation, institutional collectivism, in-group collectivism, gender egalitarianism, power distance, and uncertainty avoidance)* are the primary measures of interest for us. For each of these scales, questions assessed participants' idea regarding both the practices *(as is)* as well as the values *(should be)* in *organizations* and *society*.

As high wind blows on high hills, there are limitations with the GLOBE project as with any other research paper. Hofstede [17] provides an overview of similarities and differences between the GLOBE study and his own work [16]. One of his major concerns is that the questionnaire items might not have captured what the researchers had in mind, and, that the complete GLOBE questionnaire has not been published. Hofstede is well-known for his work on national value differences while employed by IBM. Five dimensions of national culture were identified based upon results from a survey completed by 117.000 IBM employees. Both GLOBE and Hofstede's IBM studies make sense of culture within an industrial setting. On the other hand, the GLOBE involved managers, whereas the IBM study involved seven categories of employees, of which two were managerial categories [17] of employees. While it can be expected that the GLOBE project will either be loved or hated by scholars, in a way like the IBM study [21], for us the most important fact is that both studies provide empirical evidence that there are differences between cultures.

The next section will provide an overview of cross-cultural research in HRI.

3.2 Human-Robot Cultural differences

Several studies have been conducted in order to explain cultural differences in different situations involving robots. These situations range from a plain, general attitude to robots, to experiments involving human-robot teamwork.

Bartneck et al. [3] distributed a survey among internet users from different countries in which participants were asked to complete the Negative Attitudes towards Robots Scale (NARS) questionnaire. Results indicated cultural background significantly effected attitude towards robots.

In an unpublished experiment by Sau-Lai Lee, reported by Kiesler [24], Chinese participants viewed a video of robot interaction with an experimenter, they were asked whether or not the robot would know certain landmarks. The "cultural background" of the robot was manipulated by having the robot talk either English or Cantonese, and informing participants the robot was created in either China or New York. Based upon the origin of the robot, people had a different mental model of the robot. Lee found two relevant results providing evidence for this. First, people expected the robot to have more knowledge about famous landmarks in both countries, than about not so famous landmarks. The second, perhaps the most important: participants expected the "Chinese"

robot to know more about Chinese landmarks than the "American" robot, and vice versa. In a similar way, Trovato et al. [37] found that Egyptian and Japanese participants preferred a robot displaying a similar cultural background. A robot was programmed to greet participants in the English language with either an Arabic or Japanese accent, and performing a greeting gesture also performed by humans in that culture. It was found that Japanese participants preferred the Japanese robot, and Egyptians the Arabic robot.

Wang et al. [39] conducted a 2x2 experiment involving robots, manipulating culture and robot communication style. 320 participants, 80 Chinese dyads and 80 U.S. dyads, interacted with a robot providing advice either implicitly or explicitly. The underlying hypothesis was that since the Chinese typically prefer and implicit communication style, and U.S. people a more explicit, a robot displaying a matching communication style would be seen as a more in-group member and thus more trusted and perceived as more credible. Supporting their hypothesis, Chinese participants preferred the implicit robot whereas U.S. participants preferred the explicit robot. Furthermore, when the robot communicated in the preferred way, participants were more likely to change their decisions in order to align with the robot.

Li et al. [26] also found evidence in a HRI trial that participants from a low-context culture (Germany) had different scores with respect to the evaluation of the interaction than those from high-context cultures (Chinese and Korean).

From the above we expect people from different cultures will have different views on which behaviors are normative for a robot. Previous work with regards to cultural aspects in HRI has been limited mostly to human-robot collaborative teamwork. The work in HRI on proxemics has not yet taken culture into account, which could become a shortcoming when robots are going to interact in public spaces with people having different cultural backgrounds.

4. TOWARDS A METHODOLOGY

In this section, we will describe two major challenges we see for HRI research researching cross-cultural robot behavior. These challenges are:

1) Choosing a research methodology

2) Sampling of cultures of interest

We will describe both challenges, insofar as not discussed before, and offer our ideas to solve this in Section 4.2.

4.1 Overview of methodologies

Different methodologies have been employed in order to gather data from participants from different cultures. In this section, we will first provide an overview of different methods which have been used to find answers with regards to cross-cultural differences, both in human-human, and human-robot interaction. We will then conclude with an experimental setup.

A number of studies manipulated culture by using native students and exchange students in a lab experiment. ([4], [26], [34]). Already in the 80s, Baldassare & Feller [2] hinted that the frequent comparison of U.S. versus exchange students of a culture decreases ecological validity, because a) the students are not observed in their natural culture, b) they have been influenced by North American proxemics patterns for an undisclosed time, and c) they are not a representative sample. Wang et al. [39] collected data at two separate sites; thus using native students in both settings. However, this sample was also not representative because it only included students.

Woods et al. [40] used a method called "video-based human-robot interaction" (VHRI) in which participants viewed videos of a human interacting with a robot. Results between this video-based methodology and a lab experiment with real participants were found to be comparable.

Self-reported measures, such as questionnaires, were also frequently employed. The advantage here being able to use participants from geographically distributed locations. ([3], [11], [5]). All reported studies report having the questionnaires translated and back-translated into the participants' native language.

Two experiments made use of either scaled dolls or silhouettes in order to capture people's impression of appropriate interpersonal distance in different situations ([27], [28]). Like a lab experiment, the use of dolls does require some sort of physical location when collecting data at different sites.

All these methods have advantages and disadvantages. The first method, experiments with an actual embodied robot, would be preferred for HRI since it would provide the most realistic setting. An ideal situation would be an experiment, be it a Wizard-of-Oz experiment with one type of robot, shipped all over the world to various data collection sites. This is an utopian experiment design in a world not constrained by resources like time, money and man-hours. The other methods (VHRI studies and scaled figures) could provide a solution, albeit generalizability of the results to a real-world setting could be questioned. In the next section we propose a hybrid approach to tackle these issues.

4.2 Proposed methodology

At this moment, we are conducting a survey with this setup using stills of 3D people. This survey is currently being distributed to three countries. While data collection has not yet been finished, one of the possible issues we might face is that the results are not generalizable enough because when you approach a group, the formation of the group is going to change as soon as you approach. Therefore, the use of 3D pictures might not be a sufficient methodology to investigate cross-cultural robot spatial behavior.

Based on this insight, we propose a combination of a lab- and video study to increase ecological validity while investigating the following questions:

1) "From which angle should a robot approach a small group of people?"

2) "Do people from different cultures have significant different preferences when a robot approaches a small group of people?"

3) "Do survey-based HRI studies provide reliable results when used in lieu of experiments when evaluating robot spatial behavior?"

In our situation, we have access to two robots of similar design, at two different sites – a site in the Netherlands, and a site in Spain. We propose to run a between-groups field experiment at both locations, thus having two different cultures. In the experiment, we will ask small groups of people (3-5) to stand in a room and discuss a topic. Participants will be informed that after a minute a robot will approach the group and bring the new discussion topic. The robot will approach the group from various angles, and stop at different distances.

At one of these locations, we will make a video recording of the different experiment conditions with actors. In order to test if the behaviors are perceived equally (un-)appropriate in videos compared with the field experiment, we will distribute the video to participants from the same countries as those in the field experiment. If it turns out to be true, the questionnaire can be distributed to participants with cultural backgrounds not investigated in the field experiment.

5. CONCLUSION

Service robots start entering our daily lives. When real social robots do, an important question will be if culturally different motion behaviors are necessary for a robot guiding people with distinct different backgrounds. Previous HRI research focusing on cultural aspects does not provide indisputable results, though we find it likely these results could surface when evaluating motion behaviors with respect to different cultures.

Based upon an overview of previously used methods to evaluate cross-cultural differences we have proposed a mixed-methods method in order to evaluate cross-cultural HRI behavior preferences in a resource-efficient way.

6. ACKNOWLEDGMENTS

This work has partly been supported by the European Commission under contract number FP7-ICT-600877 (SPENCER).

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8. Appendix I

Table 3 provides the ten GLOBE clusters of societies and the respective countries within each cluster.

Table 3. GLOBE clusters. Source [13]

Anglo Cultures England, Australia, South Africa (White sample), Canada, New Zealand, Ireland, United States
Confucian Asia China, Hong Kong, Japan, Singapore, South Korea, Taiwan
Eastern Europe Albania, Georgia, Greece, Hungary, Kazakhstan, Poland, Russia, Slovenia
Germanic Europe Austria, Germany, Netherlands, Switzerland (German speaking)
Latin America Argentina, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Mexico, Venezuela.
Latin Europe France, Israel, Italy, Portugal, Spain, Switzerland (French speaking)
Nordic Europe Finland, Sweden, Denmark
Southern Asia India, Indonesia, Iran, Malaysia, Philippines, Thailand
Sub-Sahara Africa Namibia, Nigeria, South Africa (Black sample), Zambia, Zimbabwe
Middle East Egypt, Kuwait, Morocco, Qatar, Turkey